EFFECTIVENESS OF SOAP FORMULATIONS CONTAINING DEET AND PERMETHRIN AS PERSONAL PROTECTION AGAINST OUTDOOR MOSQUITOES IN MALAYSIA

H. H. YAP

School of Biological Sciences, Universiti Sains Malaysia, Penang, Malaysia

ABSTRACT. Two soap formulations, both containing 20% deet and one each containing permethrin at 0.5 and 1.0%, respectively, were applied to exposed arms and legs of volunteers as personal protection against outdoor human biting mosquitoes in six locations on Penang Island, Malaysia. The predominant mosquito species collected from these locations were *Aedes albopictus, Mansonia uniformis, Culex gelidus, Anopheles lesteri* and *Armigeres subalbatus*. Efficacy and residual effects up to 4 hours indicated good protection against these species. Reduction in mosquito landing-biting rates in treated groups ranged from 83.8 to 100.0%. At high densities, small percentages of *Ma. uniformis* and *An. lesteri* landed or bit on treated skin. Use of the soap formulations in terms of cost-effectiveness, safety and overall vector control strategy for some tropical diseases is discussed.

INTRODUCTION

Since the late 1970s, research in the development of personal protection measures against mosquitoes and other biting arthropods has been prevalent. Field studies with permethrin impregnated clothing have been shown to be effective against mosquitoes, ticks, chigger mites, phlebotomine flies, black flies and other biting flies (Breeden et al. 1982, Lindsay and McAndless 1978, Schreck et al. 1977, 1978a, 1978b, 1980, 1982). Permethrin has also been topically applied in dust formulations for human body louse control (Nassif and Kamel 1977, Nasif et al. 1980).

More recently, permethrin-impregnated mosquito nets have been shown to provide better protection than untreated nets against *Anopheles* mosquitoes (Darriet et al. 1984). Moreover, when permethrin was applied to clothing and deet was applied to exposed skin, the combination provided a high degree of protection against the bites of *Aedes taeniorhynchus* Wiedemann (Schreck et al. 1984). Pressurized sprays of permethrin and deet on clothing have also proven to be highly effective against some tick species (Mount and Snoddy 1983).

The present studies were carried out to determine the effectiveness of a soap formulation containing deet and permethrin against mosquitoes in a few selected locations on Penang Island, Malaysia. These test sites provided a spectrum of common mosquito species in Malaysia.

MATERIALS AND METHODS

The studies were carried out on Penang Island, Malaysia with an approximate land area of 320 km^2 and is situated at the northwest coast of the Malay Peninsula facing the Strait of Malacca and the Bay of Bengal. The weather of the island is essentially tropical with an average daily temperature of 27°C and a relative humidity of 60–80% year round. The central part of the island is hilly with elevations of around 450 m. The hills are covered with secondary rain forests surrounded by lowlands, coastal plains and sandy beaches.

Six rural locations on Penang Island, reflecting different ecological habitats with different predominant mosquito species, were chosen to test the efficacy of the soap formulations. Trees, shrubs and grasses are ubiquitous with human habitations dotting the landscapes in these locations. The test locations were situated in the lowland areas at or near the coastal plain. The locations were as follows: (1) Universiti Sains Malaysia, Minden Campus of about 400 hectares with well-maintained buildings and surroundings; (2) Permatang Damar Laut, a rural village at the southeast corner of the island, an area covered with double or single storey wooded houses scattered over a wide area, and the houses are without clear-cut compounds, many types of trees and shrubs are found in and around the houses; (3) Gertak Sanggul, a fishing village on the southwest shore of the island; (4) Sungai Rusa, Balik Pulau District, a rice farming village at the midwestern part of the island about 5 km from the coastline; (5) Permatang Pasir, Balik Pulau District, a rubber plantation estate adjacent to Sungai Rusa; and (6) University's Mukahead Biological Station, at the northwest tip of the island and located on the coastline surrounded by secondary forests.

Two formulations of soaps containing permethrin (cis:trans ratio: 25:75) and deet were provided by Mr. Tom Simmons. The content of deet in the two soap formulations was 20%, whereas, permethrin was present at dosage of 0.5 and 1.0% for formulation A and B, respectively.

Subjects wearing a T-shirt and long trousers exposed their untreated arms and legs to assess the density of biting/landing mosquitoes. Using

small specimen tubes, each subject collected all mosquitoes landing or biting on the exposed skin within a specific time. Depending on the density of the mosquitoes, each collecting period ranged from 20 to 60 minutes.

At each test location, 12 human subjects were employed. Four subjects were untreated checks, four subjects were treated with soap formulation A and four with formulation B. The exposed arms and legs of untreated subjects were wetted with tap water and allowed to dry naturally before the initiation of mosquito collections. For the treated subjects, the soap formulations were applied on prewetted arms and legs and a uniform film of lather was achieved by rubbing the applied surfaces vigorously. The lather was allowed to dry naturally before the initiation of the mosquito collections. At each test location, the subjects were seated at least 3 m apart in a linear arrangement around the house compounds. The untreated control subjects were seated at both ends of the linear arrangement. A total of 4 hours was allotted to assess the efficacy and residual effect of the soap formulations at each test location. The choice of the time schedules for each location corresponds with the peak biting hours of the crepuscular man-biting mosquitoes in Malaysia. In order to tie in with the peak densities of certain mosquito species, some of the experiments were carried out on two consecutive nights for 2 hours each night. To simulate the residual effect of the soap formulation at the third and fourth hours after treatment, the formulations were applied 2 hours prior to the collection of the mosquitoes on the second night. Time schedules of the collections at each test location are shown in Table 1.

At test location Permatang Damur Laut, four untreated subjects were tested against four subjects with blank soap application (soap without deet and permethrin) to ascertain the effect of the blank soap on mosquito landing-biting rates.

All the mosquitoes collected were identified with assistance from the staff of the Medical Entomology Division, Institute for Medical Research, Kuala Lumpur, Malaysia.

RESULTS AND DISCUSSION

The overall mosquito landing/biting rate per man-hour and the predominant mosquito species at each test location are shown in Table 1. The mosquito densities per man-hour ranged from a high of 51.2 at Permatang Damar Laut to a low of 4.5 at Gertak Sanggul and the predominant species at each test location varied. The differences in densities and species compositions reflected the different ecological habitats of the test locations. Thirty-one species of mosquitoes were collected from the six test locations, including 9 species of *Aedes*, 5 species of *Anopheles*, 5 species of *Armigeres*, 9 species of *Culex* and 3 species of *Mansonia* (H. H. Yap and coworkers, unpublished data). Permatang Damar Laut and Sungai Rusa had the highest diversity of species with 17 and 19 species, respectively. Of the total number of mosquitoes collected, males constituted about 5%.

Among the predominant species (Table 1), *Aedes albopictus* (Skuse) is ubiquitous on Penang Island, Malaysia. This finding confirms the results of an earlier ovitrap survey conducted for the whole of Penang Island (Yap 1975). *Aedes albopictus* is a vector for dengue and dengue

Table 1. Time schedules, mosquito densities and predominant mosquito species collected by the untreated check subjects at each of the six test locations on Penang Island, Malaysia for the efficacy studies of soap formulations.

Test locations	Time schedules for testing and collection of mosquitoes (local time)[a]	Overall mosquito landing-biting rate per man-hour (Mean ± S.E.)	Predominant mosquito species collected (% of total collection)
1. University's Minden Campus	1900–2100 hr.	27.6 ± 3.1	*Ma uniformis* (53%) *Ae. albopictus* (26%)
2. Permatang Damar Laut	1900–2100 hr.	51.2 ± 4.7	*Ma. uniformis* (70%) *Cx. fulcocephalus* (14%)
3. Gertak Sanggul	1600–2000 hr.	4.5 ± 1.6	*Ae. albopictus* (88%)
4. Sungai Rusa, Balik Pulau District	1900–2100 hr.	29.3 ± 4.4	*Cx. gelidus* (39%) *An. lesteri* (38%)
5. Permatang Pasir, Balik Pulua District	1600–2000 hr.	10.8 ± 1.9	*Ae. albopictus* (79%)
6. Mukahead Biological Station	1600–2000 hr.	6.9 ± 1.6	*Ar. subalbatus* (58%) *Ae. albopictus* (21%)

[a] For test locations with time schedules of 2-hour intervals, the experiments were repeated in two consecutive nights to assess the residual effects in a 4-hour period.

haemorrhagic fever, whereas, the other predominant species such as *Mansonia uniformis* (Theobald) and *Anopheles lesteri* (Baisas and Hu) are responsible for the transmission of Brugian filariasis and malaria, respectively, in Malaysia and other Southeast Asian countries (Yap 1984). While *Armigeres* species have not been implicated in disease transmission, *Culex gelidus* (Theobald) is a vector of Japanese B encephalitis in the Oriental region. Data from the test locations reflect only the mosquito species present during the collecting times (Table 1) between May and July 1985.

Efficacy and residual effects of these soap formulations in providing up to 4 hours protection against mosquito bites in six test locations are shown in Table 2. Reductions in landing-biting rates ranged from 83.3 to 100%. Except for 2 test locations where the mosquito densities were high, i.e., Permatang Damar Laut and Sungai Rusa, the soap formulations provided almost complete protection against mosquito bites throughout the 4-hour period. Using *t*-tests at $P = 0.01$, there is no significant differences in terms of reduction of mosquito landing-biting rates when the two soap formulations were compared. Hence, formulation A should be recommended as the permethrin content is lower. In a separate experiment at Permatang Damar Laut, landing-biting rates of untreated subjects and subjects treated with blank soap (soap without deet and permethrin) were 12.35 ± 1.33 and 11.80 ± 1.20, respectively. These results, when analyzed using *t*-tests at $P = 0.05$, indicated that the soap by itself has no effect on the landing-biting rate of the mosquitoes.

The mosquito species that were collected from the treated groups were identified separately. In Permatang Damar Laut, 78% of the mosquitoes collected posttreatment were *Ma. uniformis*. This same species constituted 70% of the mosquitoes collected in the untreated group (Table 1). Although *Mansonia* mosquitoes are the main vectors of Brugian filariasis, at present there is no effective and practical control approach for them (Yap 1985). Their immature stages have been shown to be naturally more tolerant to insecticides than other common vector mosquitoes (Yap et al. 1968). Since adults of *Mansonia* species are mostly exophilic and exophagic (Gass et al. 1982), the conventional residual wall spray may not be effective for their control (Yap 1985). In this study, the effectiveness of the soap formulations against *Mansonia* species is considered satisfactory.

In the Sungai Rusa, Balik Palau district area, 69% of the mosquitoes collected posttreatment from the treated groups were *An. lesteri*. However, when one considers the overall reduction of landing-biting rate in this test location (Table 2), the effectiveness of the soap formulations should also be considered satisfactory for *Anopheles* mosquitoes. The other mosquito species collected from treated groups include *Cx. gelidus* and *Armigeres* species.

The two active ingredients used in the soap formulations, deet and permethrin, both possess low mammalian toxicity (Kenaga and Morgan 1978). Deet has been one of the most commonly used mosquito repellents (Smith 1957). Among the synthetic pyrethroids, permethrin is one of the few compounds which is photostable and provides a longer residual effect in the environment (Barlow and Hadaway 1975, Elliott et al. 1978). The low mammalian toxicity of permethrin has been reviewed (Schreck et al. 1984, World Health Organization 1984). They indicate that it does not present a hazard to human health at the low dosages recommended for the various formulations.

During the course of a 3-month experiment

Table 2. Efficacy and residual effects of soap formulations containing permethrin and deet against outdoor mosquitoes in six locations on Penang Island, Malaysia.

Test locations	Mosquito landing/biting rate per man-hour (Mean ± S.E.) over a 4-hour period				% reduction in mosquito landing/biting rate over a 4-hour exposure period to 2 formulations[a]							
					1st hour		2nd hour		3rd hour		4th hour	
	1st hour	2nd hour	3rd hour	4th hour	A	B	A	B	A	B	A	B
1. University's Minden Campus	22.5± 2.8	53.3± 4.6	5.3± 1.2	29.3± 3.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2. Permatang Damar Laut	47.3± 3.7	53.3± 4.7	48.8± 4.2	55.5± 5.1	93.7	95.2	87.3	100.0	83.3	88.0	93.2	94.6
3. Gertak Sanggul	3.8± 1.2	7.0± 1.3	4.3± 1.8	3.0± 1.5	100.0	100.0	100.0	100.0	88.4	100.0	100.0	83.4
4. Sungai Rusa Balik Pulau District	14.3± 2.1	45.8± 3.2	23.8± 3.1	33.5± 4.0	100.0	100.0	98.9	99.0	90.6	92.7	95.5	95.6
5. Permatang Pasir Balik Pulau District	5.8± 1.3	2.5± 0.5	19.5± 2.5	15.3± 2.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.8
6. Mukahead Biological Station	8.5± 1.0	4.8± 1.2	9.0± 2.3	5.3± 1.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a] Soap formulation A contains 0.5% permethrin and 20% deet, formulation B contains 1.0% permethrin and 20% deet.

(May to July 1985), more than 10 applications of the soap formulations were used by each of the 12 volunteer subjects on their exposed arms and legs with no complaints of ill effects. The volunteers did not complain of stickiness or feeling uncomfortable with the soap formulations. However, the effect of the formulations under long-term usage is yet to be investigated.

Generally, high akalinity of soap formulations usually interferes with the action of insecticides or repellents. These new soap formulations containing deet and permethrin seem to have overcome such problems (T. Simmons, personal communication). In Malaysia, commercial mosquito repellent products containing deet in the form of a solid bar or cologne sell for around US$2.50 per item. The present individual bar of soap formulation containing deet and permethrin will cost around US$0.25 (T. Simmons, personal communication) and therefore is considered favorable in terms of cost-effectiveness.

Tropical diseases, especially mosquito-borne ones such as malaria, filariasis, dengue and dengue haemorrhagic fever, are still major health problems for people living in the tropics. The progress in controlling these diseases has not been completely satisfactory, albeit the concerted efforts of international bodies such as UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (World Health Organization 1985). The new soap formulations provide personal protection against vectors of the above diseases. More research in the use of these soap formulations should be encouraged in order to provide an additional weapon in the overall strategy of vector and disease control.

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